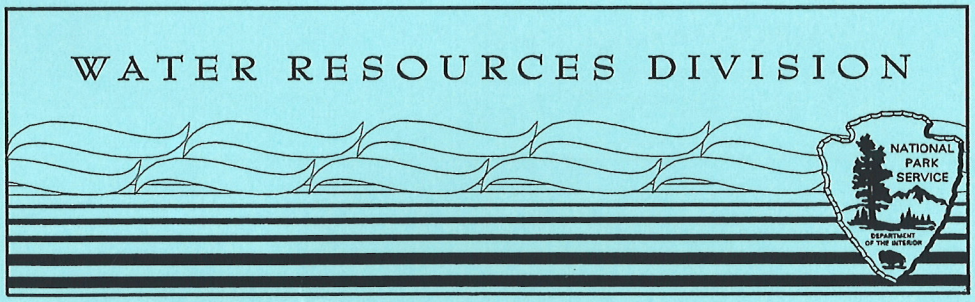
WATER QUALITY IMPACTS FROM BOAT DISCHARGES AT BRIDGE BAY MARINA IN YELLOWSTONE LAKE YELLOWSTONE NATIONAL PARK

Barry A. Long

Technical Report NPS/NRWRD/NRTR-95/67



National Park Service - Department of the Interior
Fort Collins - Denver - Washington

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September 1995

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United States Department of the Interior
National Park Service

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EXECUTIVE SUMMARY

During 1993 and 1994, Water Resources Division staff conducted synoptic water quality monitoring in Bridge Bay Marina and Yellowstone Lake in Yellowstone National Park. The purpose was to assess background levels of selected physical, chemical, and biological parameters during high and low use periods. The study was conducted in response to reports of potential water quality degradation in the marina area due to discharges from boat wastewater systems. Vertical profile measurements were taken with a multi-parameter sensor at five locations each year. Water and sediment samples were collected for laboratory analyses of selected chemical and biological constituents.

In general, water temperatures were warmer in the marina than in the lake, and warmer in summer due to the marina's shallow depth. Dissolved oxygen concentrations and pH values were higher in the marina than in the lake, and increased with depth during both years. Dissolved oxygen concentrations were higher in 1994 than 1993, but the converse was true with pH values. Conductivity values varied little with depth and among sites during both years. Only one fecal coliform bacteria colony was present in one water sample during both years. Laboratory results were relatively uniform between years, and exhibited no alarming or unusual trends, except for elevated levels of benzene, toluene, and xylene in water samples collected from two sites in the marina during 1994. These constituents are volatile organic compounds commonly found in petroleum products such as gasoline. No evidence was found that nutrient or bacterial pollution were present in the marina from boat wastewater discharges, and it appears that the park's program for inspection of sanitation devices is working and should be continued. However, these data identified the potential for organic contamination from fuels and oils that are commonly used in the marina and lake.

The Water Resources Division recommends that the park maintain a program of periodic water quality monitoring in the marina, and develop the emergency response capability to address spills and boat related accidents.

INTRODUCTION

During the fall of 1993 and summer of 1994, Water Resources Division (WRD) staff worked with Lake District staff to assess water quality at Bridge Bay Marina in Yellowstone Lake to follow-up on a technical assistance request submitted by the park, and a previous visit by WRD staff (National Park Service 1991). The park reported that water quality degradation may have occurred in the marina area due to boat discharges (greywater and sewage). Algal blooms in the marina occurred in past years and previous monitoring during 1986 and 1987 detected elevated levels of total and fecal coliform bacteria (Lewis, pers. com. 1993).

During the 1991 visit, WRD staff referred to two park memoranda (National Park Service 1989; National Park Service 1990) that reviewed the previous monitoring data and proposed implementation of an expanded monitoring plan. WRD and the park concurred that a formal monitoring program should be developed to properly address the issue. Fortunately, the park began a program of inspecting vessels for sanitation devices in 1989; however, no enforcement for greywater systems was implemented (Fey, pers. com. 1993). Therefore, it was not known whether measurable water quality degradation still was occurring as a result of boat discharges. Also, other contaminants such as petroleum products may have been dumped or washed off boats in the marina. Stormwater runoff from parking lots and nearby developed areas may have periodically degraded water quality in the marina. Since the marina has limited circulation with the lake, contaminants may have adsorbed to sediments that have been deposited in the marina over several years.

BACKGROUND

Objectives of the Synoptic Study

The WRD conducted synoptic water quality monitoring in Bridge Bay Marina and Yellowstone Lake to assess background levels of selected physical, chemical and biological parameters during high and low use periods. The objective was to conduct low use monitoring during the fall of 1993 and high use monitoring during the summer of 1994. Based on these results, recommendations would be made to the park regarding the status of water quality in the marina, the effectiveness of boat inspections in controlling pollution discharges, and long-term monitoring in the marina area.

Study Area Description

Bridge Bay Marina is located along the northwestern shore of Yellowstone Lake in Yellowstone National Park. Bridge Bay Marina is a small natural inlet that was artificially developed and dredged to provide access and moorage for boats. Bridge Bay Campground is directly adjacent to the marina, and Lake Village is only a couple miles away (Figure 1). The marina is used heavily during the summer for day-use boat launching and extended docking for larger vessels. A fueling facility is located at the

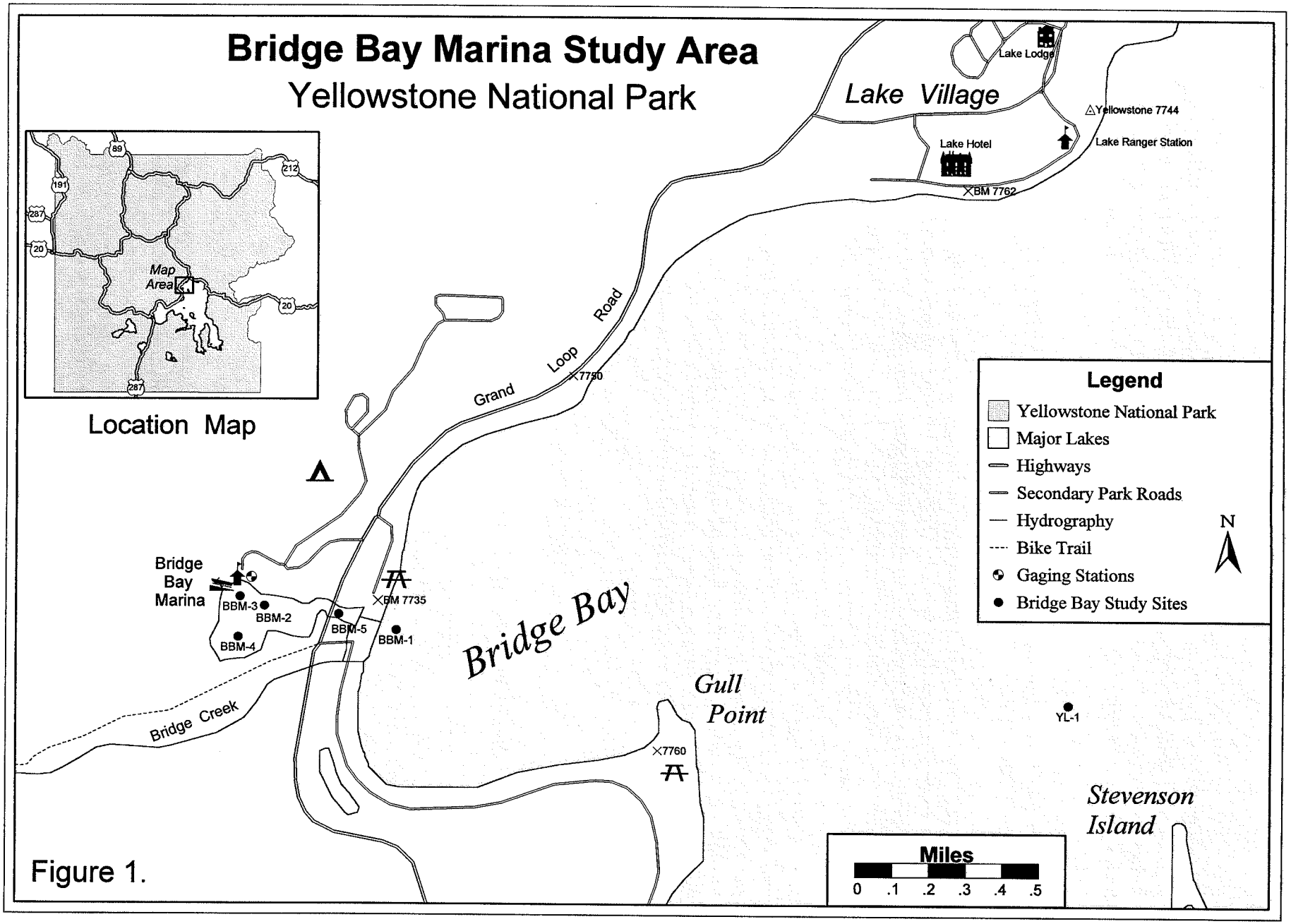
Bridge Bay Marina Study Area
Yellowstone National Park
Lake Village
Lake Lodge
Yellowstone 7744
Lake Hotel
Lake Ranger Station
BM 7762
Map Area
Location Map
Grand Loop Road
7750
Bridge Bay Marina
BBM-3
BBM-2
BBM-4
BBM-5
BBM-1
BM 7735
Bridge Bay
Bridge Creek
Gull Point
7760
YL-1
Stevenson Island
Legend
Yellowstone National Park
Major Lakes
Highways
Secondary Park Roads
Hydrography
Bike Trail
Gaging Stations
Bridge Bay Study Sites
N
Miles
0 .1 .2 .3 .4 .5

Figure 1.

west end of the main boat ramp. Private and commercial boats are allowed to use the marina. Fishing and touring services are available from park concessionaires at the marina.

Yellowstone Lake is a natural lake formed by the filling of a collapsed caldera. The water quality in Yellowstone Lake is characteristic of a large, pristine mountain lake that has been influenced by a history of thermal activity. The lake is relatively cool (due to its depth and elevation), low in dissolved and suspended solids, low in nutrients, neutral in pH, and has a low buffering capacity. Yellowstone Lake is classified as a dimictic, oligotrophic lake (Wetzel 1983).

Study Design and Implementation

The 1993 monitoring was conducted during a trip to Yellowstone National Park to perform several technical assistance tasks (National Park Service 1994a). The 1994 monitoring was conducted during a trip to Yellowstone and Grand Teton National Parks to provide technical assistance, and attend a water resources symposium sponsored by a professional organization (National Park Service 1994b).

Five water quality monitoring sites were selected in the marina, the bay, and Yellowstone Lake (Appendix A). Three sites (BBM-2, BBM-3, BBM-4) were located within the marina. One site (BBM-1) was located in Bridge Bay near the marina entrance. The study control site (YL-1) was located in Yellowstone Lake near Stevenson Island. An additional sediment monitoring site (BBM-5) was located in the narrow entrance channel between the bay and marina.

On Friday, September 24, 1993, Barry Long met Dan Reinhart at District Headquarters and proceeded to Bridge Bay Marina where they met Rick Fey and Janet Lewis. Issues related to water quality were discussed, which included: boat sewage systems; greywater discharges from boats; fuel and oil spills; leakage and combustion products; and algal blooms due to lack of interchange with the lake. Previous monitoring was conducted by the Maintenance Division prior to the issuance of boating regulations and boat inspections (Lewis, pers. com. 1993). Another issue discussed was navigation of boats into and out of the marina during low water due to deposited sediments in the narrow channel between the marina and Bridge Bay. Periodic dredging of the sediments is being considered by the park; however, no sediment sampling had been conducted to assess whether contaminants are present and could be suspended by dredging. Water quality data were collected from the five selected monitoring sites that same day.

On Friday, July 8, 1994, Dan Reinhart, Janet Lewis and Barry Long conducted follow-up water quality monitoring in Bridge Bay Marina. The July sampling time period was selected because it represented a high recreational use period. Water quality data were collected from the same five locations using the same monitoring protocols as the fall before. In addition, sediment samples were collected from two locations (BBM-3 and BBM-5).

METHODOLOGY

Field Sampling

A park vessel was used to conduct the baseline water quality assessment of the marina and Yellowstone Lake. Vertical profile measurements were taken with a Hydrolab H20 multi-parameter sensor at five locations during both sampling periods in 1993 and 1994. The parameters measured included: water temperature, pH, specific electrical conductance, dissolved oxygen, dissolved oxygen percent saturation, turbidity, oxidation-reduction potential (redox), and depth. Turbidity and redox were substituted for dissolved oxygen percent saturation in 1994. Total and Secchi depths were measured using a fathometer and/or a Secchi disk. Water samples were collected at 1-meter depth at each location with an Alpha bottle for laboratory analysis of selected ions, nutrients, and organics. Bed sediment samples were collected with an Ekman dredge at two locations in 1994. Bacteria water samples were collected near the surface with sterilized plastic bags. Bacteria water samples were filtered and incubated on-site with portable pre-sterilized equipment. The membrane filtration technique was used to analyze for fecal coliform bacteria (American Public Health Association 1989; Environmental Protection Agency 1978). A combination 12/110-volt portable incubator was used to incubate the plates, and colonies were counted the next day.

Sample Handling

All water and sediment samples were collected in approved containers, chilled immediately with ice in a cooler, and stored chilled in the cooler during transport to the laboratory (American Public Health Association 1989). Water samples were preserved with nitric, sulfuric or hydrochloric acid if required by the contract laboratory.

Laboratory Analysis

Chemical analyses of water and sediment samples were performed by Core Laboratories in Denver, Colorado. Water samples were analyzed for selected ions, nutrients, trace elements, and organic hydrocarbons (Appendix B). Sediment samples were analyzed for a range of volatile and semi-volatile organic compounds. A quality control report was provided along with the analysis results. Additional water samples were analyzed for chlorophyll by the Environmental Health Services Laboratory at Colorado State University in Fort Collins, Colorado.

Data Management

Data were recorded in a field notebook and stored on a datalogger attached to the Hydrolab H20 multi-parameter sensor. Field and laboratory data were downloaded from the datalogger and transcribed from notes and laboratory analysis sheets into digital files on a computer. Dbase and WordPerfect tables were developed to store and display these data (Appendix C). The Dbase files will be reformatted and uploaded into the U.S. Environmental Protection Agency's STORET national water quality database.

RESULTS

Field Measurements

During the 1993 sampling, no other boats were observed on the water. The weather was sunny and unusually warm. The marina and lake did not exhibit thermal stratification; however, water temperatures in the lake dropped off considerably below 18 meters (m) in depth (Appendix D). Possibly this represented the transition from stratified to mixed conditions during fall circulation. Water temperatures in the lake ranged from 10.7 °C at the surface, to 10.4 °C between 0.5 - 16 m, to 8.6 °C at a depth of 23 m. Water temperatures were slightly warmer in the bay and marina, ranging from 11.3 °C at the surface to 10.4 °C at a depth of 4.5 m.

Measurements of pH were significantly higher in the marina than in the lake, probably due to warmer temperatures and increased biological activity. At YL-1, the pH decreased slightly with depth, ranging from 7.4 - 7.1 standard units. The pH increased with depth in the bay and marina, ranging from 7.5 - 7.8 at BBM-1, and 8.8 - 9.0 at BBM-2, BBM-3 and BBM-4.

Higher dissolved oxygen concentrations were measured in the marina than in the lake or bay. Dissolved oxygen concentrations varied little with depth in the lake, ranging from 8.1 - 8.0 milligrams per liter (mg/L) at YL-1. Dissolved oxygen concentrations increased with depth in the bay and the marina, ranging from 8.2 - 8.7 mg/L at BBM-1, and 9.5 - 10.6 mg/L at BBM-2, BBM-3 and BBM-4.

Conductivity values varied little with depth at all sampling locations, ranging from 106 microSiemens per centimeter (µS/cm) in the lake to 108 µS/cm in the marina. No fecal coliform bacteria were present in water samples from any location. In general, physical measurements made in the bay at BBM-1 exhibited values that represented a transition, or mixing, zone between the lake and marina.

During the 1994 sampling, several boats were observed on the water in the marina and lake. Boats were taking on fuel at the fuel dock, and park visitors were fishing and wading in the lake. The marina did not exhibit thermal stratification. The lake was weakly stratified and water temperatures dropped off abruptly below 9 m in depth (Appendix D). Water temperatures in the lake ranged from 11.6 °C at the surface, to 11.1 - 10.2 °C between 2 - 9 m, to 6.5 °C at a depth of 24 m. Again, water temperatures were warmer in the marina, ranging from 13.7 °C at the surface to 11.8 °C at a depth of 3.5 m.

Measurements of pH were higher in the marina than in the lake, but the differences were less pronounced than during the 1993 sampling. At YL-1, the pH decreased slightly with depth, ranging from 7.6 - 7.2 standard units. The pH increased with depth at BBM-2 and BBM-3, ranging from 7.9 - 8.5. The pH at BBM-1 and BBM-4 did not change with depth, and averaged 7.5 and 8.0, respectively.

Dissolved oxygen concentrations in the lake increased with depth from 9.4 mg/L at the surface to 10.9 mg/L at 9 m in depth, then dropped off to 9.9 mg/L at 24 m. Dissolved oxygen concentrations increased with depth in the bay and marina, ranging from 9.2 - 9.8 mg/L and 9.8 - 11.2 mg/L, respectively.

Again, conductivity values varied little with depth at all sampling locations, ranging from 96 - 97 μS/cm. No differences existed between lake and marina sites; however, conductivity values were slightly lower in 1994 than in 1993. Also, no fecal coliform bacteria were present in water samples collected from four of the five sites during 1994. One colony forming unit per 100 milliliters (cfm/100mL) was cultured from a bacteria water sample collected at BBM-3.

Field turbidity values averaged 4 nephelometric turbidity units (NTU) in the lake and 9 - 19 NTU in the bay and marina along boat traffic corridors. Redox values averaged 590 millivolts (mV) in the bay, 519 mV in the lake, and 458 mV in the marina. Higher redox values in the lake and bay reflect greater oxidizing conditions.

Laboratory Analyses

In 1993, no alarming or unusual parameter values were measured, and differences among locations generally were predictable. Water samples from the lake exhibited relatively low ionic, nutrient and sediment concentrations. Water samples from the marina exhibited similar concentrations with expected variations due to its shallow depth and lack of interchange with the lake. Total dissolved solids values ranged from 49 mg/L in the lake to 65 mg/L in the marina (Appendix E). Total suspended solids values ranged from 4 mg/L in the lake to 15 mg/L in the marina. Nutrient levels were below or near laboratory detection limits in water samples from all sampling locations. No organic hydrocarbons were present in water samples from any location. Chlorophyll values were higher in the marina than in the lake, most likely due to warmer temperatures and increased biological activity.

In 1994, few changes were detected in most parameters that were analyzed in water, except for pH, benzene, toluene, and xylene (Appendix E). Slight changes were detected in total dissolved solids, total suspended solids, turbidity and chlorophyll, but they were probably not significant. One ammonia nitrogen value at BBM-4 was relatively high (0.20 mg/L); however, this may reflect the analysis of an unrepresentative sample or an error. Several trace elements (including metals) were analyzed from water samples collected in 1994. Most of these results were at or below laboratory detection limits. Aluminum, iron, strontium, and zinc were the only metals detected in samples from all of the monitoring sites.

Relatively high levels of volatile organic compounds (i.e. benzene, toluene, and xylene) were detected in water samples collected from BBM-2 and BBM-3. Benzene, in particular, was measured at 0.7 micrograms per liter (μg/L) at both sites, and may be of concern because of its harmful effects on humans and aquatic organisms. Epidemiological studies have established a causal relationship between benzene and

acute myeloid leukemia (Agency for Toxic Substances Disease Registry 1993). Benzene, toluene, and xylene occur naturally in coal tar, crude oil and gasoline.

Inductively Coupled Plasma laboratory scans of sediments collected at BBM-3 and BBM-5 detected measurable levels of several trace elements measured in milligrams per kilogram (mg/Kg), including: aluminum, arsenic, barium, beryllium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, silver, sodium, strontium, titanium, vanadium, and zinc. Although some values appeared high (e.g. 1,720 and 1,350 mg/Kg aluminum, 25 mg/Kg barium, 930 mg/Kg calcium, 680 mg/Kg magnesium, 2,000 mg/Kg iron, 300 mg/Kg sodium, 144 mg/Kg titanium, 44 mg/Kg zinc, etc.), most represented normal background conditions and/or low pollution levels. Lead values were 14 and 9 mg/Kg at both sites. GC/MS scans on sediment samples detected no semivolatile organics above a detection limit of 1,650 micrograms per kilogram (μg/Kg) using Environmental Protection Agency Method 8270 (except one due to laboratory contamination).

State of Wyoming Water Quality Standards Analysis

Only one parameter value (0.1 mg/L selenium at BBM-3 on 7/6/94) exceeded Wyoming water quality standards (Appendix E). However, several pH values measured in the marina on 9/23/93 were very close to exceeding the maximum pH standard of 9.0 standard units. In addition, benzene values from BBM-3 and BBM-4 and an ammonia nitrogen value from BBM-4 on 7/8/94 were relatively close to exceeding their respective standards. It was difficult to assess whether values for some trace elements and organics exceeded water quality standards or concern levels in sediments because of high laboratory detections limits.

DISCUSSION AND RECOMMENDATIONS

Significance of Water Quality Indicators

The water quality parameters selected for this study provided an adequate snapshot assessment of potential contaminants that were suspected to be impacting water quality and aquatic resources. These results do not necessarily represent baseline conditions or indicate whether recreational use and development in and around Yellowstone Lake are degrading water resources. That is beyond the scope of this synoptic study. Only severe degradation could have been obvious from these data. The WRD recommends that park staff continue monitoring in Bridge Bay Marina on a periodic basis to corroborate these results. Nutrients, bacteria, and hydrocarbons are parameters that should be included in this monitoring program. Inexpensive test kits are available for ammonia, nitrate, and orthophosphate. Immunoassay kits are available for rapid determination of hydrocarbons in water and sediments. Filtration kits, media and incubators are available for culturing bacteria water samples in the field. Lastly, a simple conductivity meter with a temperature sensor is very useful for monitoring changes that may indicate water quality problems.

Water Quality Standards Compliance

Based on the data collected, compliance with water quality standards is not a pervasive issue in Bridge Bay Marina or Yellowstone Lake. The single violation of the Wyoming water quality standard for selenium at BBM-3 in 1994 was at the laboratory detection limit for that parameter. The high pH values at all the marina sites during the fall of 1993 may be explained by biological activity influenced by high water temperatures and the lack of circulation with the lake. However, high benzene levels during the summer high use period in 1994 may suggest that under certain conditions contamination from petroleum products may become an issue at Bridge Bay Marina. Benzene generally is not persistent in surface water environments because of its volatile nature, and continued detection of benzene may indicate a constant input of the contaminant.

Developing a Long-Term Monitoring Program

The development of a long-term monitoring program for Yellowstone Lake was discussed with park staff. Bridge Bay Marina continues to receive heavy use during the summer months. Other areas in Yellowstone Lake may be impacted by recreational use and development as well. While at the park, four backcountry camp sites were visited by boat. Physical water quality parameters were measured and bacteria water samples were collected at Plover Point, Wolf Point, Eagle Bay, and Frank Island. No fecal coliform colonies were detected in samples collected off shore near these areas; however, turbidity levels appeared slightly elevated at Wolf Point and Eagle Bay (52 and 67 NTUs respectively). Also, new development near Lake Village, Bridge Bay, Fishing Bridge, Grant Village, and road construction work on the East Entrance Road between Fishing Bridge and Sylvan Pass may have disturbed sensitive areas in the vicinity of Yellowstone Lake, Sylvan Lake, and Eleanor Lake. Due to these and other activities, targeted monitoring on a routine basis is warranted to assess whether changes in water quality and aquatic habitat are occurring. Selecting monitoring sites and reliable indicators of contamination, scheduling, monitoring logistics, sample analysis, and data management are all factors that must be considered before embarking on a monitoring program. The *Baseline water quality data inventory and analysis report for Yellowstone National Park* (National Park Service 1994c) should be utilized to help identify where monitoring insufficiencies may exist.

CONCLUSIONS

The monitoring data collected during the fall of 1993 represented a satisfactory baseline for comparison with data from the summer of 1994. However, monitoring was limited to five sampling locations at two points in time, and seasonal and event-driven changes are likely to occur which may produce rapid responses in an oligotrophic lake. Therefore, it is recommended that additional water and sediment samples be collected during various hydrologic seasons to determine whether possible effects were undetected during previous monitoring, and to maintain a limited monitoring program to assure boat sanitation compliance in the future.

Water quality data collected as part of this study failed to reveal evidence of nutrient and bacterial pollution in Bridge Bay Marina that could be attributed to discharges from boat wastewater systems. This may be a result of the park's ongoing program for inspection of sanitation devices on boats. This program appears to be working and should be continued in the future. However, these data identified the potential for organic contamination from hydrocarbon fuels and oils that are used in the marina and the lake. Leakage from tanks and fuel lines, uncombusted fuels from motorboat exhausts, and washing or dumping of fuels and oils from boats on the water are potential sources of organic contaminants that are difficult to control by simple boat inspections. In addition, dilution and wave action effects may mask potential water quality impacts from a variety of sources. The WRD recommends that the park should develop some form of emergency response capability that can quickly assess and limit potential impacts from spills, leaks, equipment failures, and/or other accidents.

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APPENDICES

Appendix A

Site Identification Codes and Site Names

Site Identification Codes And Site Names

Site Identification Code	Site Name	Site Description
YL-1	Yellowstone Lake #1	800 Meters Northwest of Stevenson Island
BBM-1	Bridge Bay Marina #1	At Mouth of Marina in Bridge Bay
BBM-2	Bridge Bay Marina #2	End of Gangway Between Docks D and E
BBM-3	Bridge Bay Marina #3	Between Government Dock and Launch Ramp
BBM-4	Bridge Bay Marina #4	100 Meters Off South Shore of Marina
BBM-5	Bridge Bay Marina #5	Channel Between Marina and Bridge Bay

Appendix B

List Of Parameters and Laboratory Detection Limits

PARAMETERS AND DETECTION LIMITS FOR WATER AND SEDIMENT ANALYSES (1993-94)			
PARAMETER	**DETECTION LIMITS**	**PARAMETER**	**DETECTION LIMITS**
Alkalinity, Total	5 mg/L	Nickel, Total	0.04 mg/L and 4 mg/Kg
Carbon, Total Organic	2 mg/L	Potassium, Total	5 mg/L and 500 mg/Kg
Chloride, Total	0.5 mg/L	Selenium, Total	0.1 mg/L and 10 mg/Kg
Conductivity	1 µS/cm	Silver, Total	0.01 mg/L and 1 mg/Kg
Hardness, Total	1 mg/L	Sodium, Total	1 mg/L and 100 mg/Kg
Nitrogen, Ammonia	0.01 mg/L	Strontium, Total	0.01 mg/L and 1 mg/Kg
Nitrogen, Total Kjeldahl	1 mg/L	Titanium, Total	0.05 mg/L and 1 mg/Kg
Nitrogen, Nitrate	0.1 mg/L	Vanadium, Total	0.05 mg/L and 5 mg/Kg
Nitrogen, Nitrite	0.01 mg/L	Zinc, Total	0.01 mg/L and 1 mg/Kg
Nitrogen, Nitrate + Nitrite	0.05 mg/L	Benzene	0.5 µg/L
pH	0.01 SU	Toluene	0.5 µg/L
Phosphate, Ortho	0.01 mg/L	Ethyl Benzene	0.5 µg/L
Phosphorus, Total	0.01 mg/L	Xylene	0.5 µg/L
Solids, Total Dissolved	10 mg/L	Total Petroleum Hydrocarbon	1 mg/L
Solids, Total Suspended	4 mg/L	Total Extractable Hydrocarbon	0.5 mg/L
Sulfate	10 mg/L	Total Volatile Petroleum Hydrocarbon	0.3 mg/L
Turbidity	0.05 NTU	Chlorophyll-a	0.1 mg/m^3
Aluminum, Total	0.05 mg/L and 5 mg/Kg	Chlorophyll-b	0.2 mg/m^3
Antimony, Total	0.1mg/L and 10 mg/Kg	Chlorophyll-c	0.2 mg/m^3
Arsenic, Total	0.05 mg/L and 5 mg/Kg	All Base/Neutral/Acid Organics in Sediments except for those noted below	1650 µg/Kg
Barium, Total	0.01 mg/L and 1 mg/Kg		
Beryllium, Total	0.005 mg/L and 0.5 mg/Kg	Benzyl Alcohol	3300 µg/Kg
Boron, Total	0.05 mg/L and 5 mg/Kg	4-Chloroaniline	3300 µg/Kg
Cadmium, Total	0.005 mg/L and 0.5 mg/Kg	3,3-Dichlorobenzidine	3300 µg/Kg
Calcium, Total	0.1 mg/L and 10 mg/Kg	o-Nitroaniline	8250 µg/Kg
Chromium, Total	0.01 mg/L and 1 mg/Kg	m-Nitroaniline	8250 µg/Kg
Cobalt, Total	0.03 mg/L and 3 mg/Kg	p-Nitroaniline	8250 µg/Kg
Copper, Total	0.01 mg/L and 1 mg/Kg	Benzoic Acid	8250 µg/Kg
Iron, Total	0.03 mg/L and 3 mg/Kg	4-Chloro-3-methylphenol	3300 µg/Kg
Lead, Total	0.05 mg/L and 5 mg/Kg	2,4-Dinitrophenol	8250 µg/Kg
Magnesium, Total	0.1 mg/L and 10 mg/Kg	2-Methyl-4,6-dinitrophenol	8250 µg/Kg
Manganese, Total	0.01 mg/L and 1 mg/Kg	4-Nitrophenol	8250 µg/Kg
Molybdenum, Total	0.05 mg/L and 5 mg/Kg	Pentachlorophenol	8250 µg/Kg

Appendix C

Water Quality Database File Structures

The following table provides the DBASE IV database field structure for all water quality data measured in the field. These data will allow the park or other interested parties to replicate the tables and graphs contained in this report, perform statistical analyses, or to establish a baseline park water quality database. Values equalling -9 in the database represent missing data. BRIDGEFLD.DBF in DBASE IV format, contains 21 fields from site_id through redox.

BRIDGEFLD.DBF				
Field Name	**Field Type**	**Width/# Decimal places**	**Parameter STORET No.**	**Field Description**
SITE_ID	Character	5		Identification code for sample location
DATE	Date	8		Date sample taken [mm/dd/yy]
TIME	Character	4		Time sample taken [hhmm]
SITE_NAME	Character	18		Name of sample location
STORET_NO	Character	6		STORET number of sample location
PARK	Character	5		NPS unit containing sample location
COUNTY	Character	3		County containing sample location
UTM	Character	12		Universal Transverse Mercator coordinates of sample location
ELEV	Character	5		Elevation of sample location in feet
OBSERVER	Character	22		Names of persons who performed sampling
SAMPLE_TYP	Character	7		Type of sample taken (grab, water, sediment)
LAB_NO	Character	9		Number of the lab that performed analysis
AGENCY	Character	5		Agency that performed sampling
DEPTH	Numeric	9/1		Depth that measurement was taken: (m)

BRIDGEFLD.DBF				
Field Name	**Field Type**	**Width/# Decimal places**	**Parameter STORET No.**	**Field Description**
H2O_TEMP	Numeric	9/1	00010	Temperature, water: °C
PH	Numeric	9/2	00400	pH, field: standard units
DO	Numeric	9/2	00300	Oxygen, dissolved: mg/L
DO_%SAT	Numeric	9/1	00301	Oxygen, dissolved, percent of saturation: %
EC	Numeric	9	00094	Specific conductance, field: µS/cm
TURBIDITY	Numeric	9/1	82078	Turbidity, field: NTU
REDOX	Numeric	9	00090	Oxidation-Reduction Potential (ORP): mV

The following table provides the DBASE IV database field structure for all water quality data analyzed in the laboratory. These data will allow the park or other interested parties to replicate the tables and graphs contained in this report, perform statistical analyses, or to establish a baseline park water quality database. Values equalling -9 in the database represent missing data. BRIDGELAB.DBF in DBASE IV format, contains 67 fields from site_id through f_coliform.

BRIDGELAB.DBF				
Field Name	**Field Type**	**Width/# Decimal places**	**Parameter STORET No.**	**Field Description**
SITE_ID	Character	5		Identification code for sample location
DATE	Date	8		Date sample taken [mm/dd/yy]
TIME	Character	4		Time sample taken [hhmm]
SITE_NAME	Character	18		Name of sample location
STORET_NO	Character	6		STORET number of sample location
PARK	Character	5		NPS unit containing sample location
COUNTY	Character	3		County containing sample location
UTM	Character	12		Universal Transverse Mercator coordinates of sample location
ELEV	Character	5		Elevation of sample location in feet
OBSERVER	Character	22		Names of persons who performed sampling
SAMPLE_TYP	Character	7		Type of sample taken (grab, water, sediment)
LAB_NO	Character	9		Number of the lab that performed analysis
AGENCY	Character	5		Agency that performed sampling

BRIDGELAB.DBF				
Field Name	**Field Type**	**Width/# Decimal places**	**Parameter STORET No.**	**Field Description**
DEPTH	Numeric	9/1		Depth that sample was collected: (m)
ALKALINITY	Numeric	9	00410	Alkalinity, total (as $CACO_3$): mg/L
TOC	Numeric	9	00680	Carbon, total organic: mg/L
CHLORIDE	Numeric	9/1	00940	Chloride, total: mg/L
EC_LAB	Numeric	9	00095	Specific conductance, lab: µS/cm
HARDNESS	Numeric	9	00900	Hardness, total (as $CaCO_3$): mg/L
AMMONIA	Numeric	9/2	00610	Nitrogen, ammonia, total (as N): mg/L
TKN	Numeric	9/1	00625	Nitrogen, Kjeldahl, total (as N): mg/L
NITRATE	Numeric	9/1	00620	Nitrogen, nitrate, total (as N): mg/L
NITRITE	Numeric	9/2	00615	Nitrogen, nitrite, total (as N): mg/L
NO2_NO3	Numeric	9/2	00630	Nitrogen, nitrate plus nitrite, total (as N): mg/L
PH_LAB	Numeric	9/2	00403	pH, lab: standard units
ORTHO_P	Numeric	9/2	70507	Phosphate, ortho (as P): mg/L
T_PHOS	Numeric	9/2	00665	Phosphorus, total (as P): mg/L
TDS	Numeric	9	70300	Residue, total filtrable: mg/L (Total Dissolved Solids)
TSS	Numeric	9	00530	Residue, total nonfiltrable: mg/L (Total Suspended Solids)

BRIDGELAB.DBF				
Field Name	**Field Type**	**Width/# Decimal places**	**Parameter STORET No.**	**Field Description**
SULFATE	Numeric	9	00945	Sulfate, total: mg/L
TURBID_LAB	Numeric	9/2	82079	Turbidity, lab: NTU
ALUMINUM_T	Numeric	9/2	01105	Aluminum, total: µg/L
ANTIMONY_T	Numeric	9/1	01097	Antimony, total: µg/l
ARSENIC_T	Numeric	9/2	01002	Arsenic, total: µg/L
BARIUM_T	Numeric	9/2	01007	Barium, total: µg/L
BERYLLIUM_T	Numeric	9/3	01012	Beryllium, total: µg/L
BORON_T	Numeric	9/2	01022	Boron, total: µg/L
CADMIUM_T	Numeric	9/3	01027	Cadmium, total: µg/L
CALCIUM_T	Numeric	9/1	00916	Calcium, total: mg/L
CHROMIUM_T	Numeric	9/2	01034	Chromium, total: µg/L
COBALT_T	Numeric	9/2	01037	Cobalt, total: µg/L
COPPER_T	Numeric	9/2	01042	Copper, total: µg/L
IRON_T	Numeric	9/2	01045	Iron, total: µg/L
LEAD_T	Numeric	9/2	01051	Lead, total: µg/L
MAGNESIUM_T	Numeric	9/1	00927	Magnesium, total: mg/L
MANGANESE_T	Numeric	9/2	01055	Manganese, total: µg/L
MOLYBDENUM_T	Numeric	9/2	01062	Molybdenum, total: µg/L
NICKEL_T	Numeric	9/2	01067	Nickel, total: µg/L
POTASSIUM_T	Numeric	9	00937	Potassium, total: mg/L
SELENIUM_T	Numeric	9/1	01147	Selenium, total: µg/L
SILVER_T	Numeric	9/2	01077	Silver, total: µg/L
SODIUM_T	Numeric	9/1	00929	Sodium, total: mg/L
STRONTIUM_T	Numeric	9/2	01082	Strontium, total: µg/L
TITANIUM_T	Numeric	9/2	01152	Titanium, total: µg/l
VANADIUM_T	Numeric	9/2	01087	Vanadium, total: µg/l

BRIDGELAB.DBF				
Field Name	**Field Type**	**Width/# Decimal places**	**Parameter STORET No.**	**Field Description**
ZINC_T	Numeric	9/2	01092	Zinc, total: µg/l
BENZENE	Numeric	9/1	34030	Benzene: µg/L
TOLUENE	Numeric	9/1	34010	Toluene: µg/L
ETHYL_BENZENE	Numeric	9/1	34371	Ethyl benzene: µg/L
XYLENE	Numeric	9/1	34020	Xylene: µg/L
TPH	Numeric	9/1	45501	Total Petroleum Hydrocarbon: mg/L
TEH	Numeric	9/1		Total Extractable Hydrocarbon: mg/L
TVPH	Numeric	9/1		Total Volatile Petroleum Hydrocarbon: mg/L
CHLOROPHYLL-A	Numeric	9/1	32211	Chlorophyll-a: mg/m^3
CHLOROPHYLL-B	Numeric	9/1	70973	Chlorophyll-b: mg/m^3
CHLOROPHYLL-C	Numeric	9/1	32215	Chlorophyll-c: mg/m^3
F_ COLIFORM	Numeric	9	31616	Fecal coliform, M-FC broth, 0.45mm filter: cfu/100 mL

A one-character field follows each water quality parameter. The fields are for Environmental Protection Agency STORET remark codes, if needed. Each field is labeled with the letter R followed by the appropriate STORET parameter number.

Appendix D

Field Measurement Tables and Graphs

FIELD MEASUREMENTS (9/24/93)
Yellowstone National Park

Location: **YELLOWSTONE LAKE #1** (800 Meters Northwest of Stevenson Island)

Secchi Depth: 9.2 meters (wavy)

Total Depth: 28.0 meters

Vertical Profile Measurements:

Time (hrs)	Temp. (° C)	pH (SU)	EC (µS/cm)	DO sat. (%)	DO (mg/L)	Depth (m)
1202	10.7	7.40	106.1	73.3	8.10	0.3
1203	10.6	7.39	106.0	73.5	8.13	0.5
1204	10.6	7.39	106.0	73.5	8.13	1.0
1205	10.6	7.40	106.0	73.4	8.12	2.0
1206	10.6	7.40	106.0	73.4	8.12	3.0
1208	10.4	7.41	105.9	73.1	8.12	4.0
1209	10.4	7.41	106.0	73.1	8.12	5.0
1210	10.4	7.40	105.9	73.1	8.12	6.0
1211	10.4	7.41	106.0	73.0	8.11	7.0
1212	10.4	7.41	106.0	72.8	8.09	8.0
1213	10.4	7.41	106.0	72.9	8.10	9.0
1214	10.4	7.41	106.0	72.9	8.11	10.0
1216	10.4	7.42	106.1	72.8	8.10	12.0
1217	10.4	7.40	106.1	72.7	8.08	14.0
1219	10.4	7.39	106.1	72.3	8.04	16.0
1221	10.0	7.31	106.0	70.9	7.94	18.0
1222	9.8	7.26	106.0	70.6	7.96	20.0
1223	9.0	7.19	105.6	69.8	8.02	22.0
1225	8.6	7.09	105.7	69.4	8.04	23.0

Location: **BRIDGE BAY MARINA #1** (At Mouth of Marina and Bridge Bay)

Secchi Depth: 4.6+ meters

Total Depth: 4.6 meters

Vertical Profile Measurements:

Time (hrs)	Temp. (° C)	pH (SU)	EC (µS/cm)	DO sat. (%)	DO (mg/L)	Depth (m)
1424	11.1	7.50	106.7	75.2	8.23	0.5
1425	11.1	7.52	106.8	75.2	8.23	1.0
1426	11.0	7.52	106.8	75.2	8.23	1.5
1428	11.0	7.53	106.8	75.3	8.24	2.0
1429	11.0	7.54	106.8	75.6	8.29	2.5
1430	11.0	7.54	106.7	76.0	8.34	3.0
1431	10.9	7.59	106.7	76.5	8.40	3.5
1432	10.9	7.69	106.7	77.7	8.53	4.0
1434	10.9	7.75	106.7	79.3	8.72	4.5

Location: **BRIDGE BAY MARINA #2** (End of Gangway Between Docks D and E)

Secchi Depth: 3.4 meters

Total Depth: 3.6 meters

Vertical Profile Measurements:

Time (hrs)	Temp. (° C)	pH (SU)	EC (µS/cm)	DO sat. (%)	DO (mg/L)	Depth (m)
1516	10.7	8.79	106.8	87.6	9.67	0.5
1517	10.8	8.82	106.9	87.2	9.61	1.0
1518	10.6	8.88	106.9	88.8	9.83	1.5
1519	10.6	8.83	107.0	88.6	9.80	2.0
1521	10.5	8.89	107.1	88.3	9.80	2.5
1524	10.4	8.97	107.2	91.6	10.18	3.0
1525	10.4	9.03	107.6	95.8	10.64	3.5

Location: **BRIDGE BAY MARINA #3** (Between Government Dock and Launch Ramp)

Secchi Depth: 3.0 meters

Total Depth: 3.0 meters

Vertical Profile Measurements:

Time (hrs)	Temp. (° C)	pH (SU)	EC (µS/cm)	DO sat. (%)	DO (mg/L)	Depth (m)
1601	11.3	8.83	107.8	86.8	9.45	0.5
1602	11.0	8.84	107.7	86.8	9.51	1.0
1602	11.1	8.86	107.8	86.5	9.47	1.5
1603	10.8	8.88	107.7	86.9	9.55	2.0
1604	10.6	8.95	107.6	90.1	9.97	2.5
1606	10.6	8.96	107.6	90.7	10.02	3.0

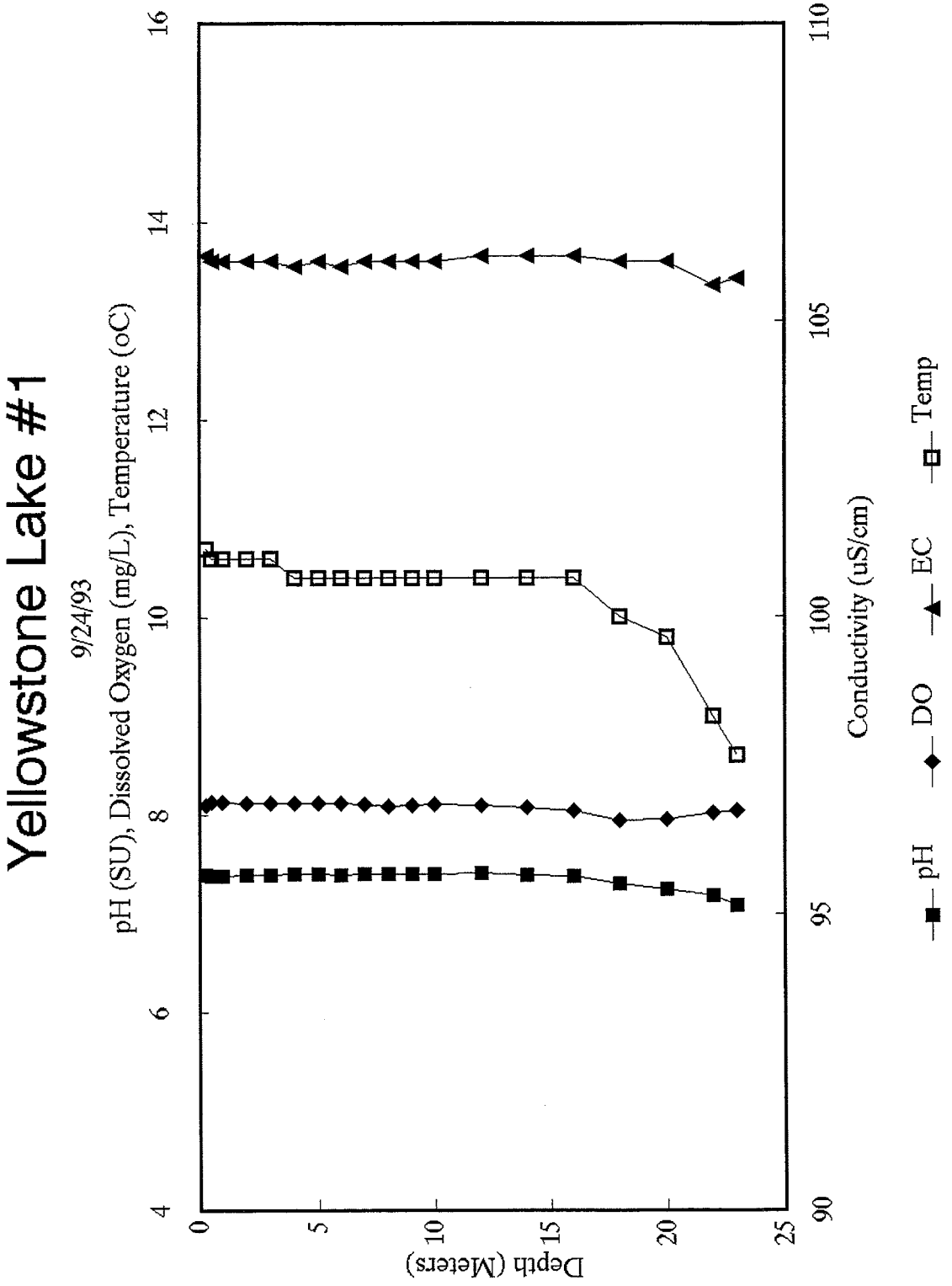
Location: **BRIDGE BAY MARINA #4** (100 meters off South Shore of Marina)

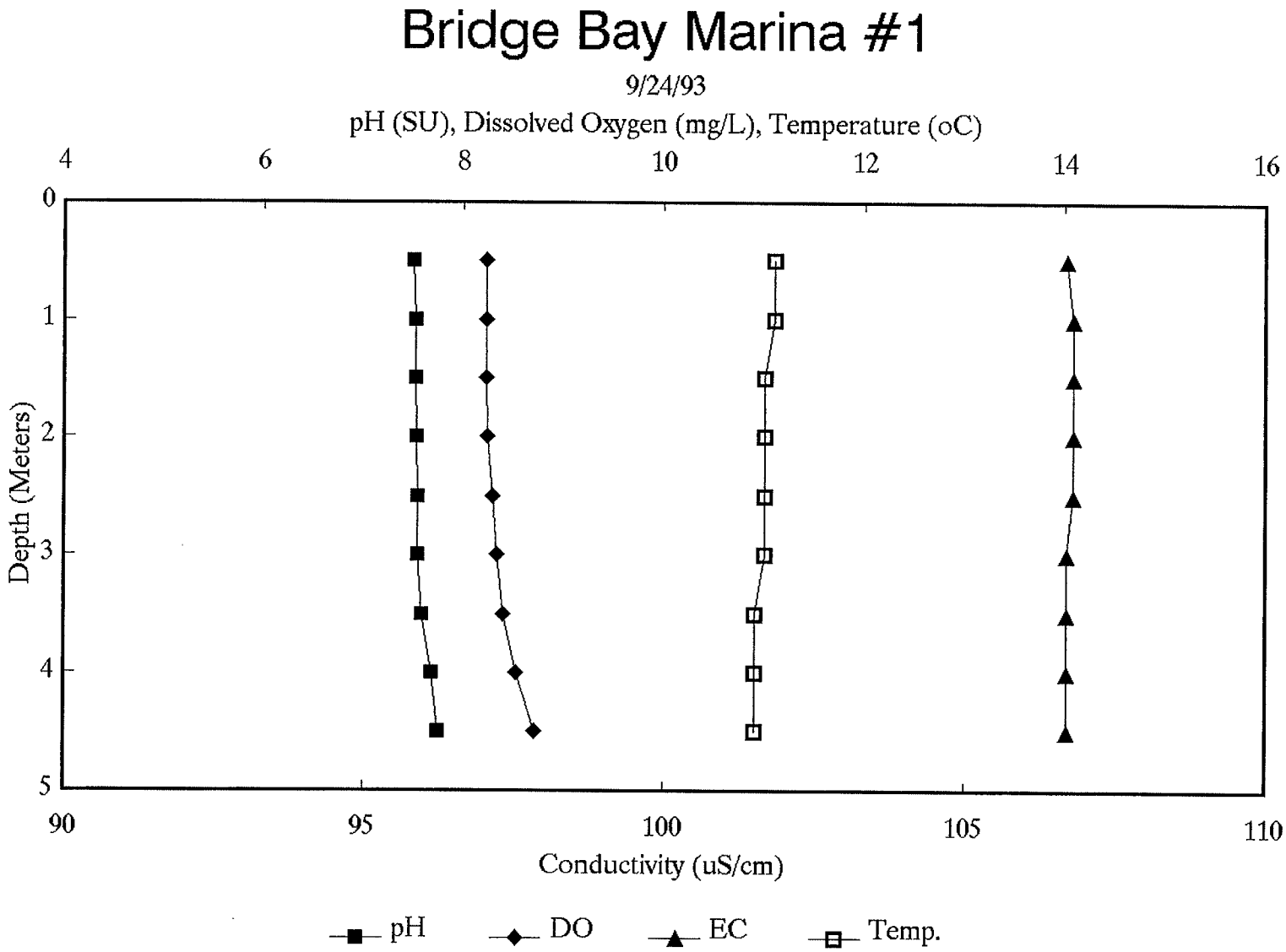
Secchi Depth: 3.1 meters

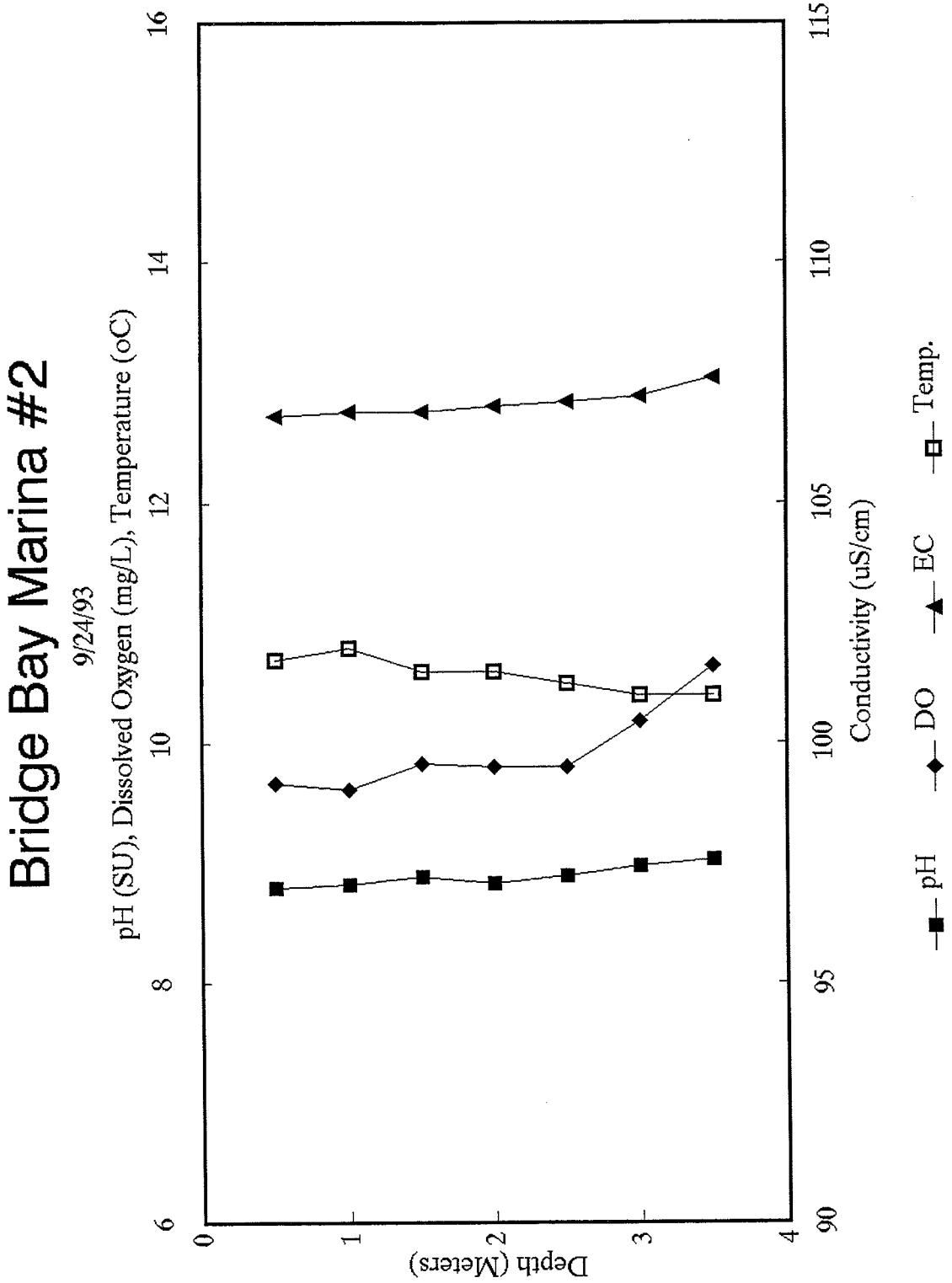
Total Depth: 3.1 meters

Vertical Profile Measurements:

Time (hrs)	Temp. (° C)	pH (SU)	EC (µS/cm)	DO sat. (%)	DO (mg/L)	Depth (m)
1657	11.0	8.82	108.4	86.5	9.47	0.5
1658	11.0	8.83	108.2	86.4	9.47	1.0
1700	11.0	8.86	108.1	86.1	9.43	1.5
1701	11.0	8.88	108.1	86.1	9.43	2.0
1702	10.6	8.98	108.0	90.7	10.03	2.5
1703	10.6	8.99	107.9	93.4	10.34	3.0


Yellowstone Lake #1
9/24/93
pH (SU), Dissolved Oxygen (mg/L), Temperature (oC)
Conductivity (uS/cm)
Depth (Meters)
pH
DO
EC
Temp
4
6
8
10
12
14
16
90
95
100
105
110
0
5
10
15
20
25

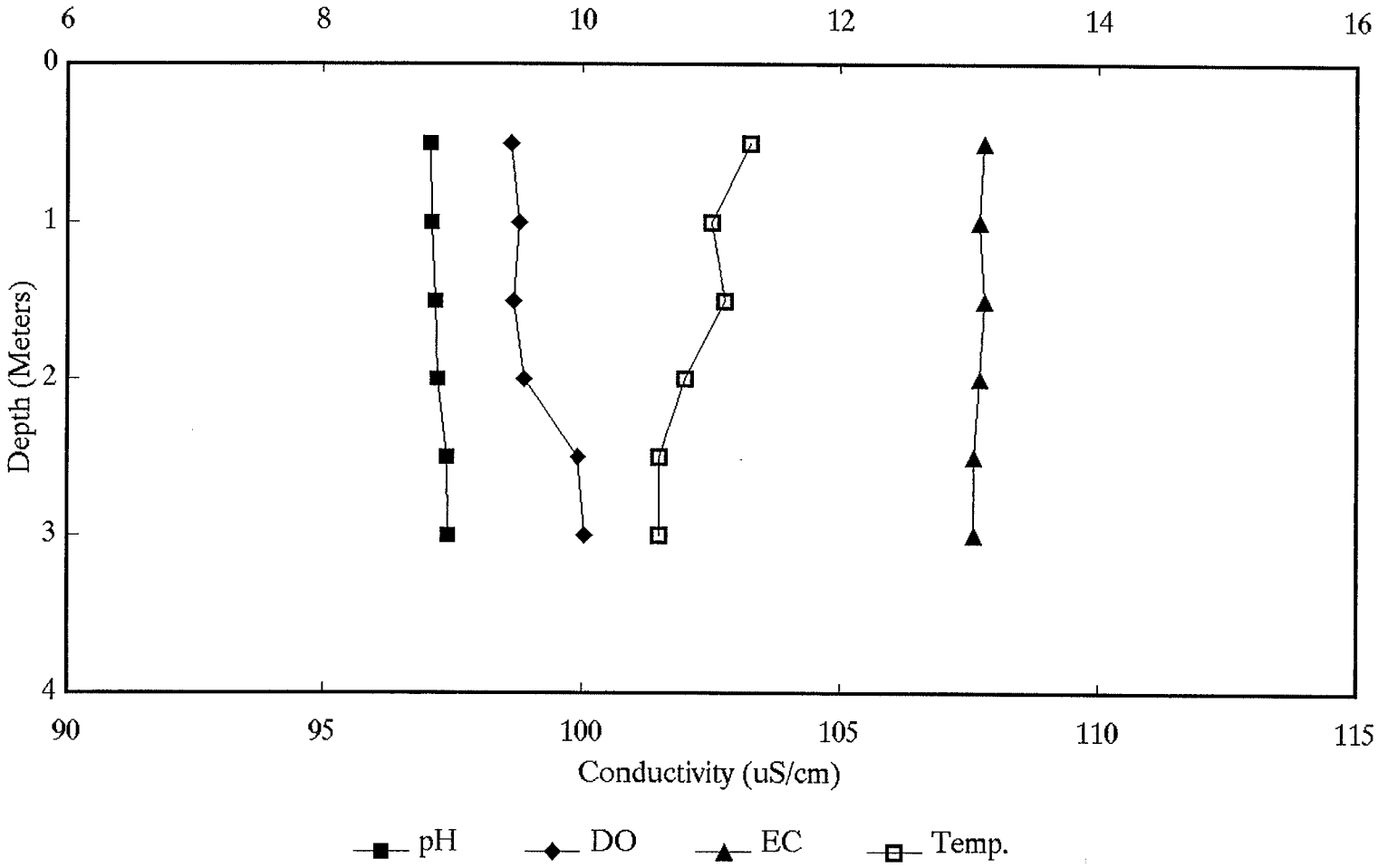

Bridge Bay Marina #1
9/24/93
pH (SU), Dissolved Oxygen (mg/L), Temperature (oC)
4
6
8
10
12
14
16
0
1
2
3
4
5
Depth (Meters)
90
95
100
105
110
Conductivity (uS/cm)
pH
DO
EC
Temp.

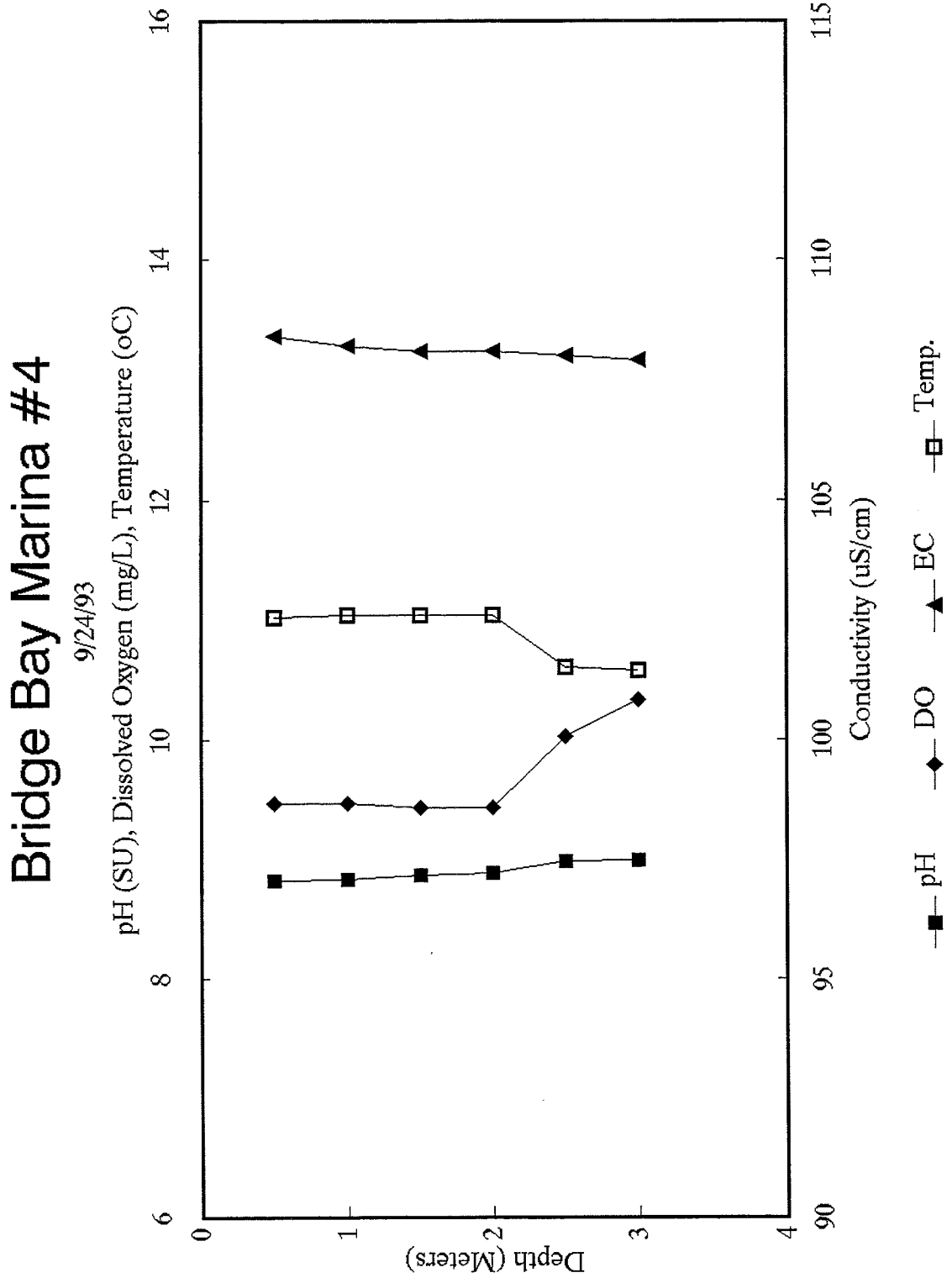

Bridge Bay Marina #2
9/24/93
pH (SU), Dissolved Oxygen (mg/L), Temperature (oC)
Conductivity (uS/cm)
Depth (Meters)
pH
DO
EC
Temp.
6
8
10
12
14
16
90
95
100
105
110
115
0
1
2
3
4

Bridge Bay Marina #3

9/24/93

pH (SU), Dissolved Oxygen (mg/L), Temperature (oC)




Bridge Bay Marina #4
9/24/93
pH (SU), Dissolved Oxygen (mg/L), Temperature (oC)
Conductivity (uS/cm)
Depth (Meters)
pH
DO
EC
Temp.
6
8
10
12
14
16
90
95
100
105
110
115
0
1
2
3
4

FIELD MEASUREMENTS (7/8/94)
Yellowstone National Park

Location: **YELLOWSTONE LAKE #1** (800 Meters Northwest of Stevenson Island)

Secchi Depth: 8.7 meters (wavy)

Total Depth: 29.0 meters

Vertical Profile Measurements:

Time (hrs)	Temp. (° C)	pH (SU)	EC (µS/cm)	Redox (mV)	DO (mg/L)	Turbidity (NTU)	Depth (m)
–							
1140	11.6	7.58	96.0	492	9.40	6.5	0.5
1142	11.4	7.50	96.0	495	9.56	6.6	1.0
1143	11.1	7.47	96.0	504	9.64	5.3	2.0
1145	10.9	7.46	96.0	506	9.62	5.2	3.0
1147	10.8	7.47	96.0	508	9.58	4.7	4.0
1148	10.8	7.49	96.0	513	9.72	4.4	5.0
1149	10.8	7.49	96.0	514	9.62	4.1	6.0
1151	10.6	7.50	96.0	515	10.50	4.1	7.0
1152	10.4	7.49	96.0	516	10.62	4.0	8.0
1154	10.2	7.46	96.0	518	10.90	4.0	9.0
1156	9.9	7.45	96.0	522	10.51	3.7	10.0
1157	9.2	7.38	96.0	526	10.20	3.5	12.0
1159	8.5	7.32	96.0	530	10.00	3.5	14.0
1200	8.0	7.26	97.0	533	9.83	2.9	16.0
1222	7.5	7.23	97.0	536	9.72	2.7	18.0
1224	7.0	7.18	97.0	539	9.76	2.6	20.0
1226	6.7	7.17	97.0	540	9.88	2.4	22.0
1227	6.5	7.15	97.0	542	9.90	2.2	24.0

Location: **BRIDGE BAY MARINA #1** (At Mouth of Marina and Bridge Bay)

Secchi Depth: 5.4 meters (wavy)

Total Depth: 5.4 meters

Vertical Profile Measurements:

Time (hrs)	Temp. (° C)	pH (SU)	EC (µS/cm)	Redox (mV)	DO (mg/L)	Turbidity (NTU)	Depth (m)
–							
1030	11.2	7.50	97.0	589	9.20	----	0.5
1032	11.1	7.46	97.0	592	9.30	20.5	1.0
1033	11.1	7.46	97.0	593	9.32	18.0	1.5
1034	11.1	7.46	97.0	592	9.31	18.6	2.0
1036	11.0	7.46	97.0	592	9.30	18.7	2.5
1037	11.0	7.43	97.0	592	9.43	19.1	3.0
1039	10.6	7.41	97.0	592	9.43	19.3	3.5
1040	10.0	7.41	96.0	593	9.60	20.0	4.0
1042	10.0	7.43	96.0	591	9.70	19.7	4.5
1044	10.0	7.47	96.0	574	9.75	17.7	5.0

Location: **BRIDGE BAY MARINA #2** (End of Gangway Between Docks D and E)

Secchi Depth: 2.7 meters

Total Depth: 4.0 meters

Vertical Profile Measurements:

Time (hrs)	Temp. (° C)	pH (SU)	EC (µS/cm)	Redox (mV)	DO (mg/L)	Turbidity (NTU)	Depth (m)
–							
1440	12.8	7.87	96.5	446	9.88	12.5	0.5
1442	12.9	7.83	96.5	449	9.90	15.6	1.0
1444	12.7	7.83	96.5	453	10.00	12.3	1.5
1445	12.4	7.95	96.5	450	10.18	13.3	2.0
1447	12.3	7.98	96.7	452	10.20	12.5	2.5
1448	12.0	8.15	96.7	449	10.54	11.5	3.0
1450	11.8	8.46	97.0	438	11.20	10.3	3.5

Location: **BRIDGE BAY MARINA #3** (Between Government Dock and Launch Ramp)

Secchi Depth: 2.9 meters

Total Depth: 3.9 meters

Vertical Profile Measurements:

Time (hrs)	Temp. (° C)	pH (SU)	EC (µS/cm)	Redox (mV)	DO (mg/L)	Turbidity (NTU)	Depth (m)
–							
1550	13.4	8.01	97.0	461	9.80	6.0	0.5
1551	13.1	8.00	97.0	461	10.06	6.9	1.0
1552	12.8	8.00	97.3	462	10.16	7.5	1.5
1553	12.6	8.10	96.7	460	10.43	10.1	2.0
1554	12.4	8.20	96.7	457	10.55	9.3	2.5
1555	12.3	8.27	97.0	454	10.80	11.2	3.0
1557	12.2	8.32	97.0	453	11.00	13.8	3.5

Location: **BRIDGE BAY MARINA #4** (100 meters off South Shore of Marina)

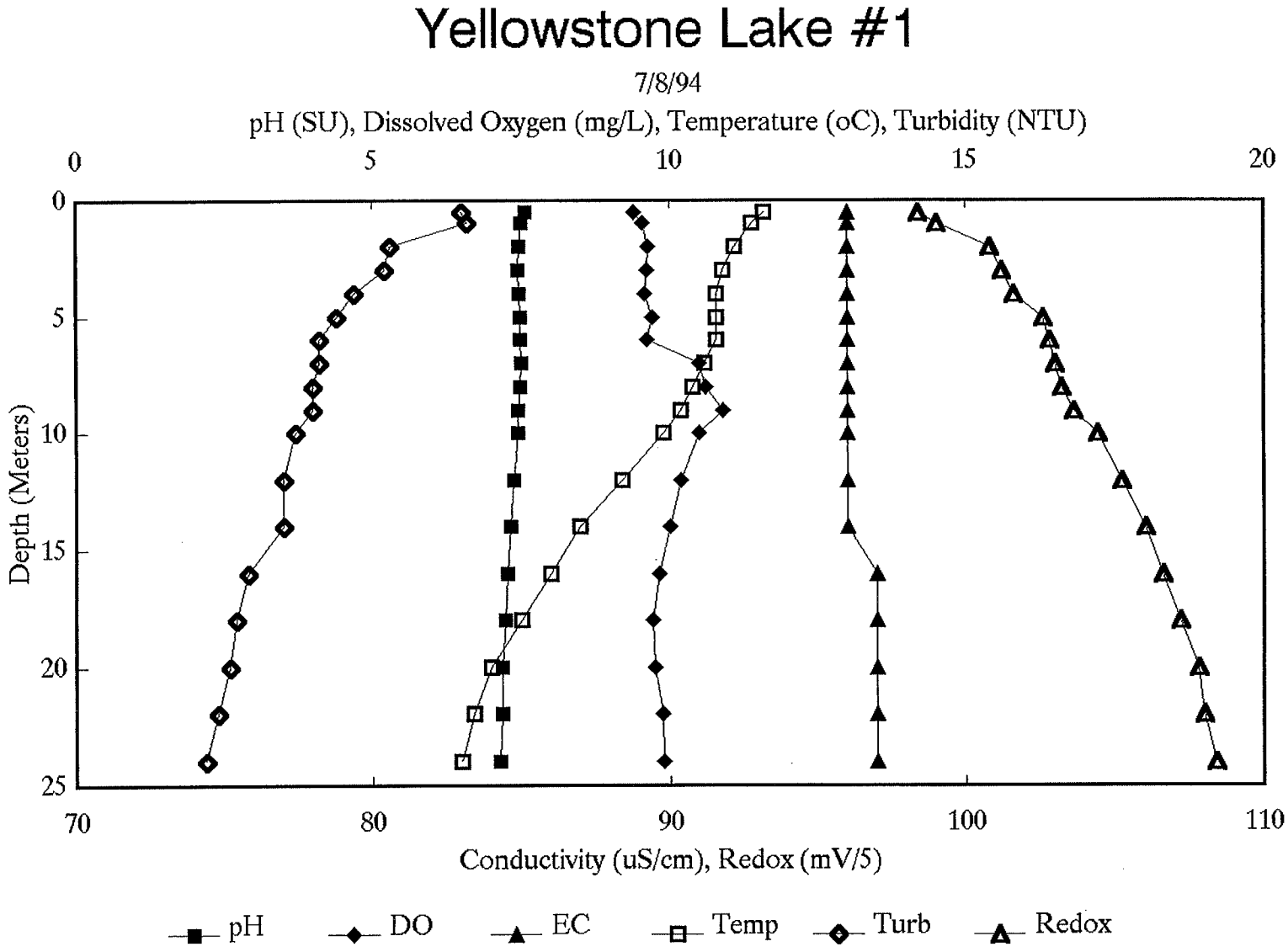
Secchi Depth: 3.4 meters

Total Depth: 3.8 meters

Vertical Profile Measurements:

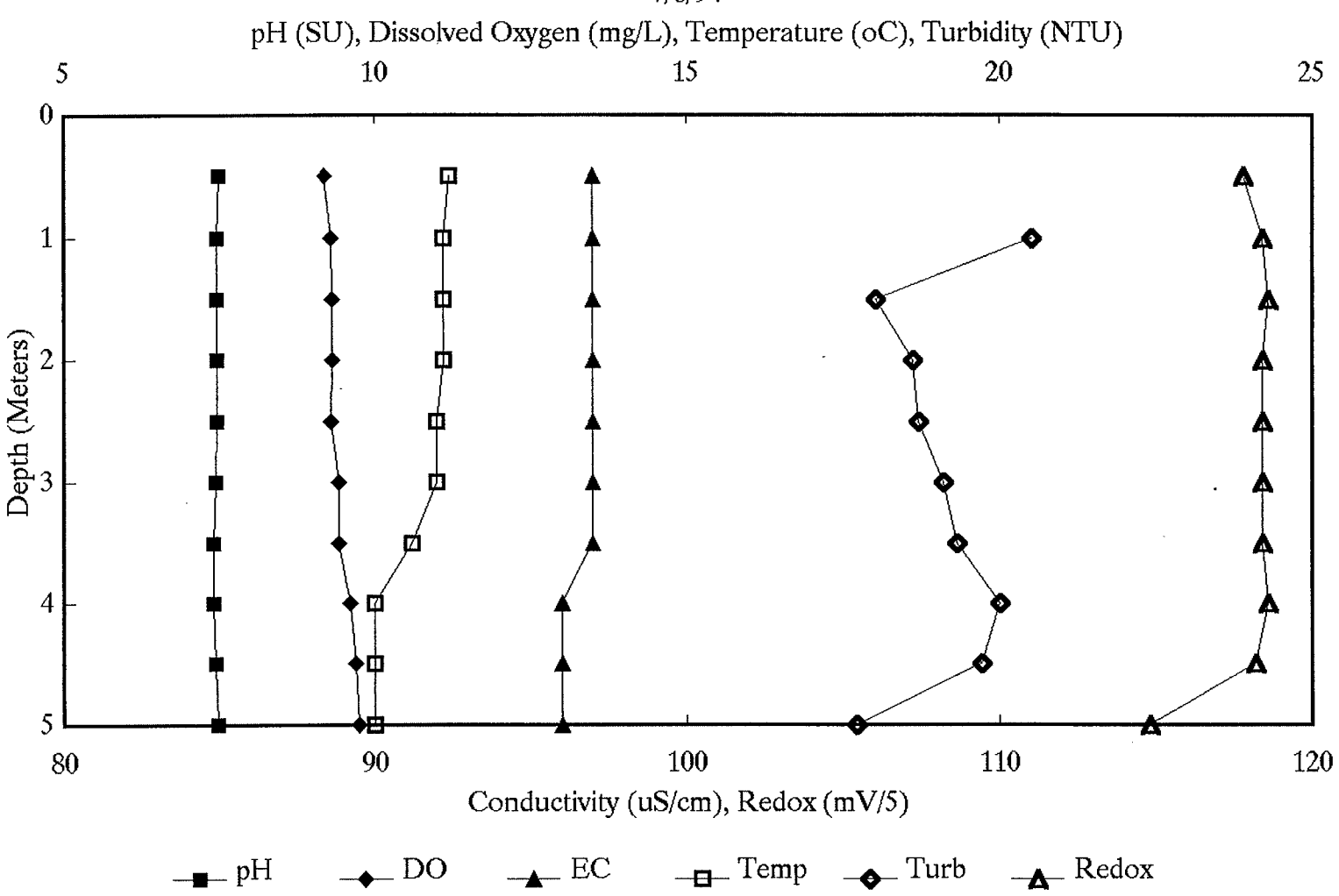
Time (hrs)	Temp. (° C)	pH (SU)	EC (µS/cm)	Redox (mV)	DO (mg/L)	Turbidity (NTU)	Depth (m)
–							
1530	13.7	7.95	97.0	461	9.80	5.1	0.5
1531	13.4	7.95	97.2	466	9.87	4.3	1.0
1532	13.3	7.94	97.3	467	9.95	4.2	1.5
1533	12.7	7.94	97.1	468	10.00	3.9	2.0
1534	12.6	7.93	97.1	470	10.00	3.0	2.5
1535	12.2	8.00	96.8	467	10.25	4.5	3.0
1537	12.2	7.95	96.7	470	10.30	6.0	3.5

Yellowstone Lake #1



Bridge Bay Marina #1

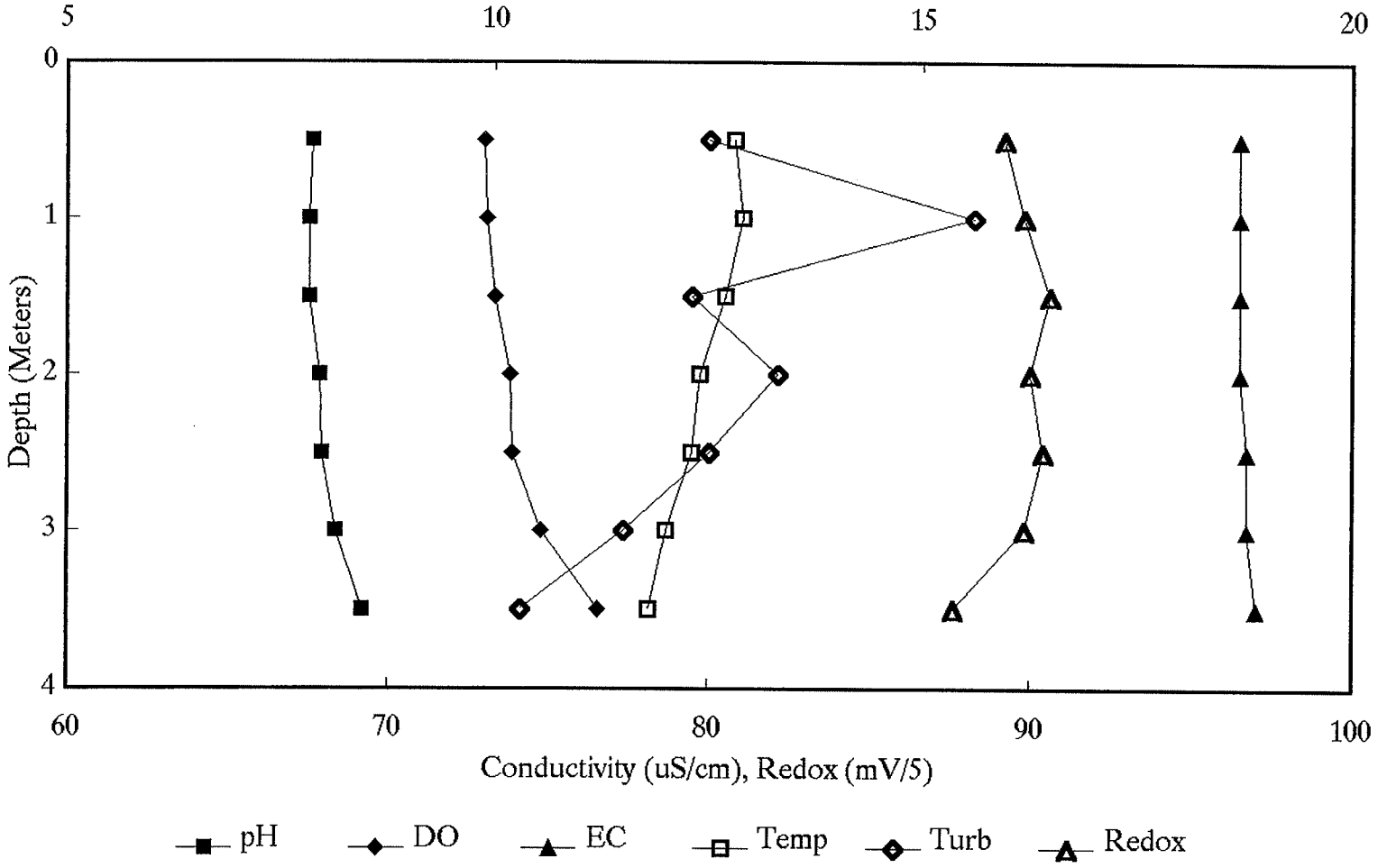
7/8/94



Bridge Bay Marina #2

7/8/94

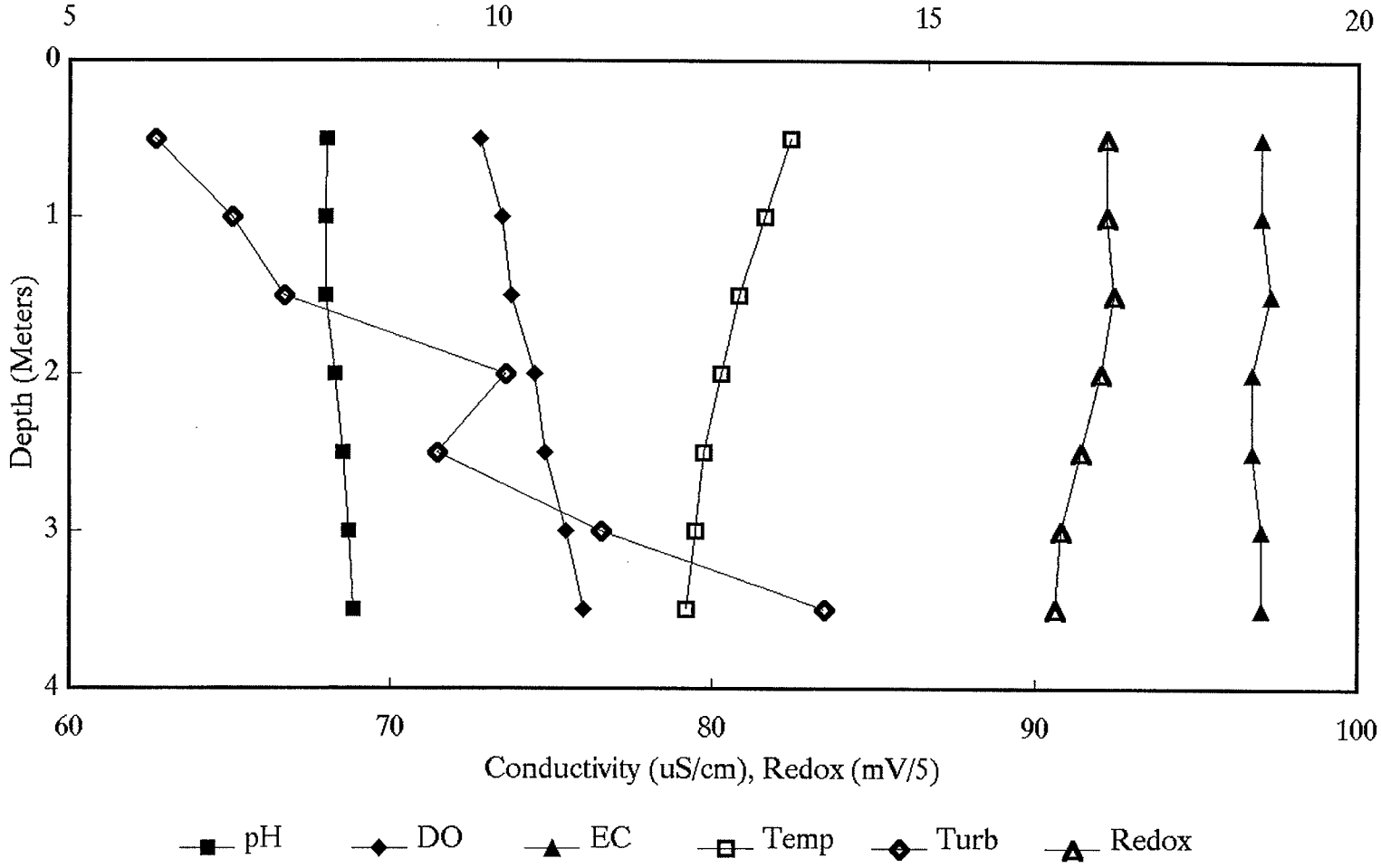
pH (SU), Dissolved Oxygen (mg/L), Temperature (oC), Turbidity (NTU)

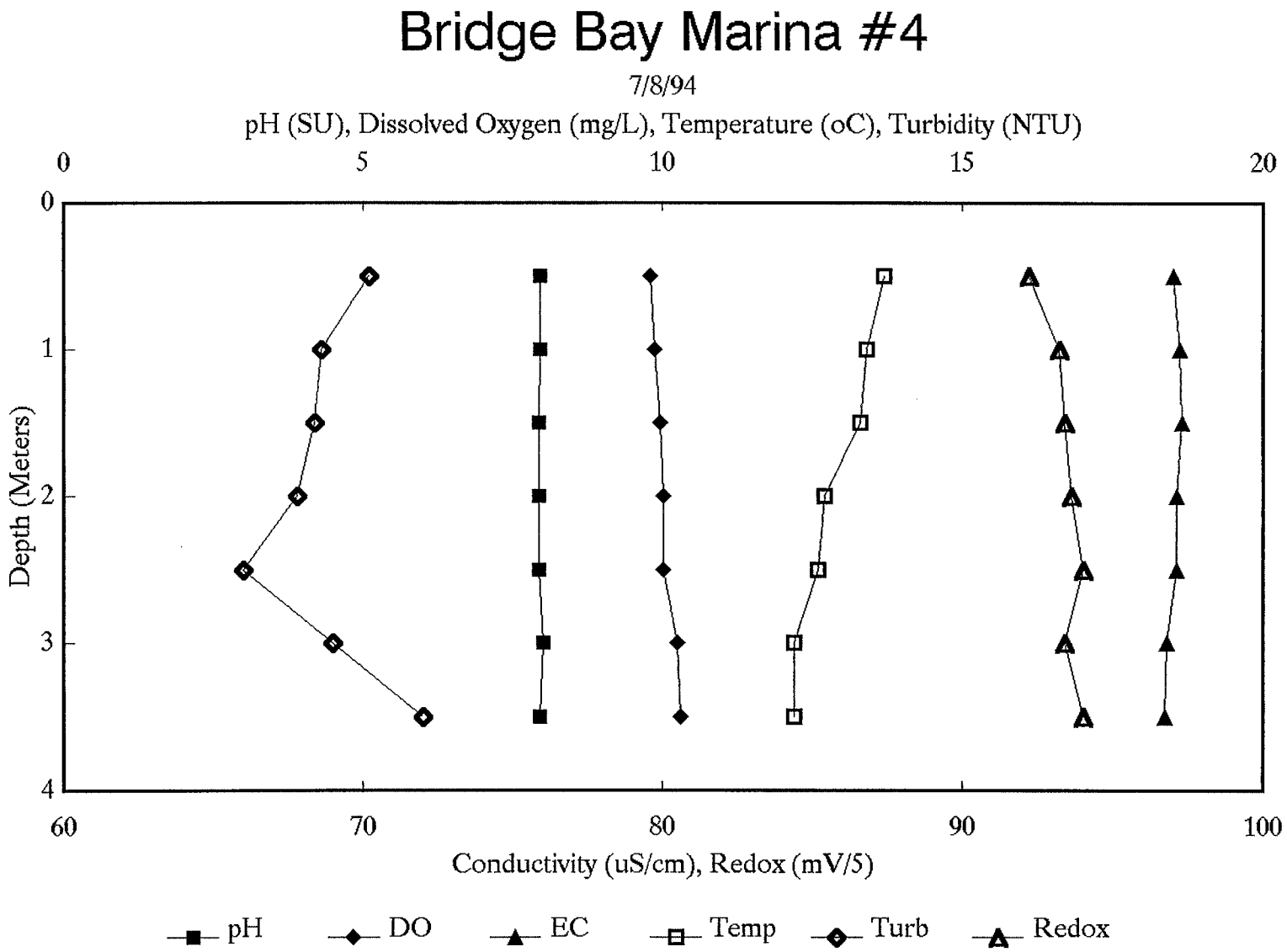


Bridge Bay Marina #3

7/8/94

pH (SU), Dissolved Oxygen (mg/L), Temperature (oC), Turbidity (NTU)




Bridge Bay Marina #4
7/8/94
pH (SU), Dissolved Oxygen (mg/L), Temperature (oC), Turbidity (NTU)
0
5
10
15
20
Depth (Meters)
0
1
2
3
4
60
70
80
90
100
Conductivity (uS/cm), Redox (mV/5)
pH
DO
EC
Temp
Turb
Redox

Appendix E

Laboratory Analysis Tables

LABORATORY WATER ANALYSIS RESULTS (9/24/93) Bridge Bay Marina, Yellowstone National Park						
VARIABLE DESCRIPTION	**YL-1**	**BBM-1**	**BBM-2**	**BBM-3**	**BBM-4**	**WYO STAND**
Alkalinity, Total (mg/L)	31	33	32	32	33	
Carbon, Total Organic (mg/L)	2	2	3	3	5	
Chloride (mg/L)	5.2	5.2	5.1	5.0	5.0	860
Conductivity (µS/cm)	98	97	98	98	98	
Hardness, Total (mg/L)	23	21	21	22	22	
Nitrogen, Ammonia (mg/L as N)	0.02	0.03	0.02	0.02	<0.01	0.68[A]
Nitrogen, Total Kjeldahl (mg/L as N)	<1	<1	<1	<1	<1	
Nitrogen, Nitrate (mg/L as N)	<0.1	0.1	0.1	<0.1	0.1	10.0
Nitrogen, Nitrite (mg/L as N)	<0.01	<0.01	<0.01	<0.01	<0.01	
pH (SU)	7.76	7.78	8.86	8.83	8.82	6.5-9
Phosphate, Ortho (mg/L as P)	0.01	0.01	<0.01	<0.01	<0.01	
Phosphorus, Total (mg/L as P)	0.02	0.02	0.02	0.02	0.02	
Solids, Total Dissolved (mg/L)	49	57	60	63	65	
Solids, Total Suspended (mg/L)	4	4	9	6	15	
Sulfate (mg/L)	<10	<10	<10	<10	<10	
Turbidity (NTU)	0.71	0.65	2.1	2.0	1.8	10[B]
Calcium (mg/L)	5.0	4.6	4.5	4.8	4.9	
Magnesium (mg/L)	2.5	2.3	2.4	2.5	2.5	
Benzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	1.2
Toluene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	6800

LABORATORY WATER ANALYSIS RESULTS (9/24/93) Bridge Bay Marina, Yellowstone National Park						
VARIABLE DESCRIPTION	**YL-1**	**BBM-1**	**BBM-2**	**BBM-3**	**BBM-4**	**WYO STAND**
Ethyl Benzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	3100
Xylene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Total Petroleum Hydrocarbon (mg/L)	<1	<1	<1	<1	<1	
Chlorophyll-a (mg/m^3)	<0.1	<0.1	2.4	<0.1	<0.1	
Chlorophyll-b (mg/m^3)	<0.2	<0.2	4.7	<0.2	<0.2	
Chlorophyll-c (mg/m^3)	1.3	0.7	10.0	5.2	4.5	
Fecal Coliform (CFU/100 mL)	0	0	0	0	0	200[C]

[A] Total ammonia calculated from un-ionized, acute standard at 10° C and pH 9.0.
[B] Turbidity increase due to activities of man.
[C] Fecal coliform standard based on a geometric mean of 5 or more samples in a 30-day period.

LABORATORY WATER ANALYSIS RESULTS (7/8/94) Bridge Bay Marina, Yellowstone National Park						
VARIABLE DESCRIPTION	**YL-1**	**BBM-1**	**BBM-2**	**BBM-3**	**BBM-4**	**WYO STAND**
Alkalinity, Total (mg/L)	31	33	33	32	33	
Carbon, Total Organic (mg/L)	2	2	2	3	2	
Chloride (mg/L)	4.8	4.1	3.9	4.3	4.0	860
Conductivity (µS/cm)	98	98	98	98	98	
Hardness, Total (mg/L)	25	23	23	23	23	
Nitrogen, Ammonia (mg/L as N)	0.02	<0.01	0.03	0.03	0.20	0.68[A]
Nitrogen, Total Kjeldahl (mg/L as N)	<1	<1	<1	<1	<1	
Nitrogen, Nitrate + Nitrite (mg/L as N)	<0.05	<0.05	<0.05	<0.05	<0.05	10.0
pH (SU)	7.47	7.58	7.44	7.64	7.54	6.5-9
Phosphate, Ortho (mg/L as P)	0.01	0.01	0.01	0.01	0.01	
Phosphorus, Total (mg/L as P)	0.02	0.02	0.02	<0.01	0.02	
Solids, Total Dissolved (mg/L)	72	68	69	70	64	
Solids, Total Suspended (mg/L)	<4	<4	<4	<4	<4	
Sulfate (mg/L)	<10	<10	<10	<10	<10	
Turbidity (NTU)	0.34	0.44	1.0	1.2	1.2	10[B]
Aluminum, Total (mg/L)	0.05	0.05	0.08	0.10	0.07	0.75
Antimony, Total (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	
Arsenic, Total (mg/L)	<0.05	<0.05	<0.05	<0.05	<0.05	0.36
Barium, Total (mg/L)	<0.01	<0.01	0.01	<0.01	0.01	1.0
Beryllium, Total (mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	
Boron, Total (mg/L)	0.12	0.12	0.14	0.12	0.17	

LABORATORY WATER ANALYSIS RESULTS (7/8/94) Bridge Bay Marina, Yellowstone National Park						
VARIABLE DESCRIPTION	**YL-1**	**BBM-1**	**BBM-2**	**BBM-3**	**BBM-4**	**WYO STAND**
Cadmium, Total (mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	0.0039[C]
Calcium (mg/L)	5.5	5.2	5.1	5.1	5.2	
Chromium, Total (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	0.10[D]
Cobalt, Total (mg/L)	<0.03	<0.03	<0.03	<0.03	<0.03	
Copper, Total (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	0.018[C]
Iron, Total (mg/L)	0.15	0.08	0.06	0.13	0.09	
Lead, Total (mg/L)	<0.05	<0.05	<0.05	<0.05	<0.05	0.082[C]
Magnesium (mg/L)	2.8	2.5	2.5	2.5	2.5	
Manganese, Total (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
Molybdenum, Total (mg/L)	<0.05	<0.05	<0.05	<0.05	<0.05	
Nickel, Total (mg/L)	<0.04	<0.04	<0.04	<0.04	<0.04	1.4[C]
Potassium, Total (mg/L)	<5	<5	<5	<5	<5	
Selenium, Total (mg/L)	<0.1	<0.1	<0.1	0.1	<0.1	0.02
Silver, Total (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	0.0041[C]
Sodium, Total (mg/L)	10	9	9	9	10	
Strontium, Total (mg/L)	0.04	0.04	0.04	0.04	0.04	
Titanium, Total (mg/L)	<0.05	<0.05	<0.05	<0.05	<0.05	
Vanadium, Total (mg/L)	<0.05	<0.05	<0.05	<0.05	<0.05	
Zinc, Total (mg/L)	0.02	0.02	0.01	0.02	0.03	0.12[C]
Benzene (µg/L)	<0.5	<0.5	0.7	0.7	<0.5	1.2
Toluene (µg/L)	<0.5	<0.5	1.2	1.2	<0.5	6800
Ethyl Benzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	3100
Xylene (µg/L)	<0.5	<0.5	1.7	1.8	<0.5	
Total Extractable Hydrocarbon (mg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	

LABORATORY WATER ANALYSIS RESULTS (7/8/94) Bridge Bay Marina, Yellowstone National Park						
VARIABLE DESCRIPTION	**YL-1**	**BBM-1**	**BBM-2**	**BBM-3**	**BBM-4**	**WYO STAND**
Total Volatile Petroleum Hydrocarbon (mg/L)	<0.3	<0.3	<0.3	<0.3	<0.3	
Chlorophyll-a (mg/m^3)	0.1	0.3	0.4	0.3	0.2	
Chlorophyll-b (mg/m^3)	<0.2	<0.2	<0.2	<0.2	<0.2	
Chlorophyll-c (mg/m^3)	0.6	0.4	0.5	1.1	1.9	
Fecal Coliform (CFU/100 mL)	0	0	0	1	0	200[E]

[A] Total ammonia calculated from un-ionized, acute standard at 10° C and pH 9.0.
[B] Turbidity increase due to activities of man.
[C] Hardness dependent criteria. Value given is based on a $CaCO_3$ hardness of 100 mg/L.
[D] Drinking water maximum contaminant level
[E] Fecal coliform standard based on a geometric mean of 5 or more samples in a 30-day period.

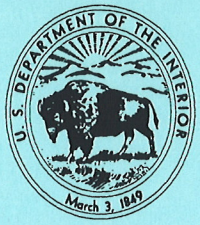
LABORATORY SEDIMENT ANALYSIS RESULTS (7/8/94) Bridge Bay Marina, Yellowstone National Park		
VARIABLE DESCRIPTION	**BBM-3**	**BBM-5**
Aluminum, Total (mg/Kg)	1720	1350
Antimony, Total (mg/Kg)	<10	<10
Arsenic, Total (mg/Kg)	<5	6
Barium, Total (mg/Kg)	25	24
Beryllium, Total (mg/Kg)	0.5	0.6
Boron, Total (mg/Kg)	<5	<5
Cadmium, Total (mg/Kg)	930	780
Chromium, Total (mg/Kg)	7	6
Cobalt, Total (mg/Kg)	<3	<3
Copper, Total (mg/Kg)	4	2
Iron, Total (mg/Kg)	2000	2000
Lead, Total (mg/Kg)	14	9
Magnesium, Total (mg/Kg)	680	570
Manganese, Total (mg/Kg)	30	21
Molybdenum, Total (mg/Kg)	<5	<5
Nickel, Total (mg/Kg)	4	<4
Potassium, Total (mg/Kg)	<500	<500
Selenium, Total (mg/Kg)	<10	<10
Silver, Total (mg/Kg)	4	4
Sodium, Total (mg/Kg)	300	300
Strontium, Total (mg/Kg)	8	7
Titanium, Total (mg/Kg)	113	144
Vanadium, Total (mg/Kg)	6	7
Zinc, Total (mg/Kg)	44	14
Acenaphthene (µg/Kg)	<1650	<1650
Acenaphthylene (µg/Kg)	<1650	<1650

LABORATORY SEDIMENT ANALYSIS RESULTS (7/8/94) Bridge Bay Marina, Yellowstone National Park		
VARIABLE DESCRIPTION	**BBM-3**	**BBM-5**
Anthracene (µg/Kg)	<1650	<1650
Benzo(a)anthracene (µg/Kg)	<1650	<1650
Benzo(b)fluoranthene (µg/Kg)	<1650	<1650
Benzo(k)fluoranthene (µg/Kg)	<1650	<1650
Benzo(ghi)perylene (µg/Kg)	<1650	<1650
Benzo(a)pyrene (µg/Kg)	<1650	<1650
Benzyl Alcohol (µg/Kg)	<3300	<3300
Butyl benzyl phthalate (µg/Kg)	<1650	<1650
Bis(2-chloroethoxy)methane (µg/Kg)	<1650	<1650
Bis(2-chloroethyl)ether (µg/Kg)	<1650	<1650
Bis(2-chloroisopropyl)ether (µg/Kg)	<1650	<1650
Bis(2-ethylhexy)phthalate (µg/Kg)	<1650	<1650
4-Bromophenyl phenyl ether (µg/Kg)	<1650	<1650
4-Chloroaniline (µg/Kg)	<3300	<3300
2-Chloronaphthalene (µg/Kg)	<1650	<1650
4-Chlorophenyl phenyl ether (µg/Kg)	<1650	<1650
Chrysene (µg/Kg)	<1650	<1650
Dibenzo(a,h)anthracene (µg/Kg)	<1650	<1650
Dibenzofuran (µg/Kg)	<1650	<1650
1,2-Dichlorobenzene (µg/Kg)	<1650	<1650
1,3-Dichlorobenzene (µg/Kg)	<1650	<1650
1,4-Dichlorobenzene (µg/Kg)	<1650	<1650
3,3-Dichlorobenzidine (µg/Kg)	<3300	<3300
Diethyl phthalate (µg/Kg)	<1650	<1650
Dimethyl phthalate (µg/Kg)	<1650	<1650
Di-n-butyl phthalate (µg/Kg)	2500[A]	2400[A]

LABORATORY SEDIMENT ANALYSIS RESULTS (7/8/94) Bridge Bay Marina, Yellowstone National Park		
VARIABLE DESCRIPTION	**BBM-3**	**BBM-5**
Di-n-octyl phthalate (µg/Kg)	<1650	<1650
2,4-Dinitrotoluene (µg/Kg)	<1650	<1650
2,6-Dinitrotoluene (µg/Kg)	<1650	<1650
Fluoranthene (µg/Kg)	<1650	<1650
Fluorene (µg/Kg)	<1650	<1650
Hexachlorobenzene (µg/Kg)	<1650	<1650
Hexachlorobutadiene (µg/Kg)	<1650	<1650
Hexachlorocyclopentadiene (µg/Kg)	<1650	<1650
Hexachloroethane (µg/Kg)	<1650	<1650
Indeno(1,2,3-cd)pyrene (µg/Kg)	<1650	<1650
Isophorone (µg/Kg)	<1650	<1650
2-Methylnaphthalene (µg/Kg)	<1650	<1650
Naphthalene (µg/Kg)	<1650	<1650
o-Nitroaniline (µg/Kg)	<8250	<8250
m-Nitroaniline (µg/Kg)	<8250	<8250
p-Nitroaniline (µg/Kg)	<8250	<8250
Nitrobenzene (µg/Kg)	<1650	<1650
N-Nitrosodi-n-propylamine (µg/Kg)	<1650	<1650
N-Nitrosodiphenylamine (µg/Kg)	<1650	<1650
Phenanthrene (µg/Kg)	<1650	<1650
Pyrene (µg/Kg)	<1650	<1650
1,2,4-Trichlorobenzene (µg/Kg)	<1650	<1650
Benzoic Acid (µg/Kg)	<8250	<8250
4-Chloro-3-methylphenol (µg/Kg)	<3300	<3300
2-Chlorophenol (µg/Kg)	<1650	<1650
2,4,-Dichlorophenol (µg/Kg)	<1650	<1650

LABORATORY SEDIMENT ANALYSIS RESULTS (7/8/94) Bridge Bay Marina, Yellowstone National Park		
VARIABLE DESCRIPTION	**BBM-3**	**BBM-5**
2,4-Dimethylphenol (µg/Kg)	<1650	<1650
2,4-Dinitrophenol (µg/Kg)	<8250	<8250
2-Methyl-4,6-dinitrophenol (µg/Kg)	<8250	<8250
o-Cresol (2-Methylphenol) (µg/Kg)	<1650	<1650
4-Methylphenol (µg/Kg)	<1650	<1650
2-Nitrophenol (µg/Kg)	<1650	<1650
4-Nitrophenol (µg/Kg)	<8250	<8250
Pentachlorophenol (µg/Kg)	<8250	<8250
Phenol (µg/Kg)	<1650	<1650
2,4,5-Trichlorophenol (µg/Kg)	<1650	<1650
2,4,6-Trichlorophenol (µg/Kg)	<1650	<1650

[A] Di-n-butyl phthalate (1700 µg/Kg) detected in method blank.



As the nation's principal conservation agency, the Department of the Interior has the responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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